



# Operations of Suborbital Research Platforms to Obtain Remote Sensing Data

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# NASA Armstrong Mission

Advancing technology  
and science through flight



X-48C

1 Perform flight research  
and technology  
integration to  
revolutionize aviation and  
pioneer aerospace  
technology

2 Validate space exploration  
concepts

3 Conduct airborne remote  
sensing and science  
observations

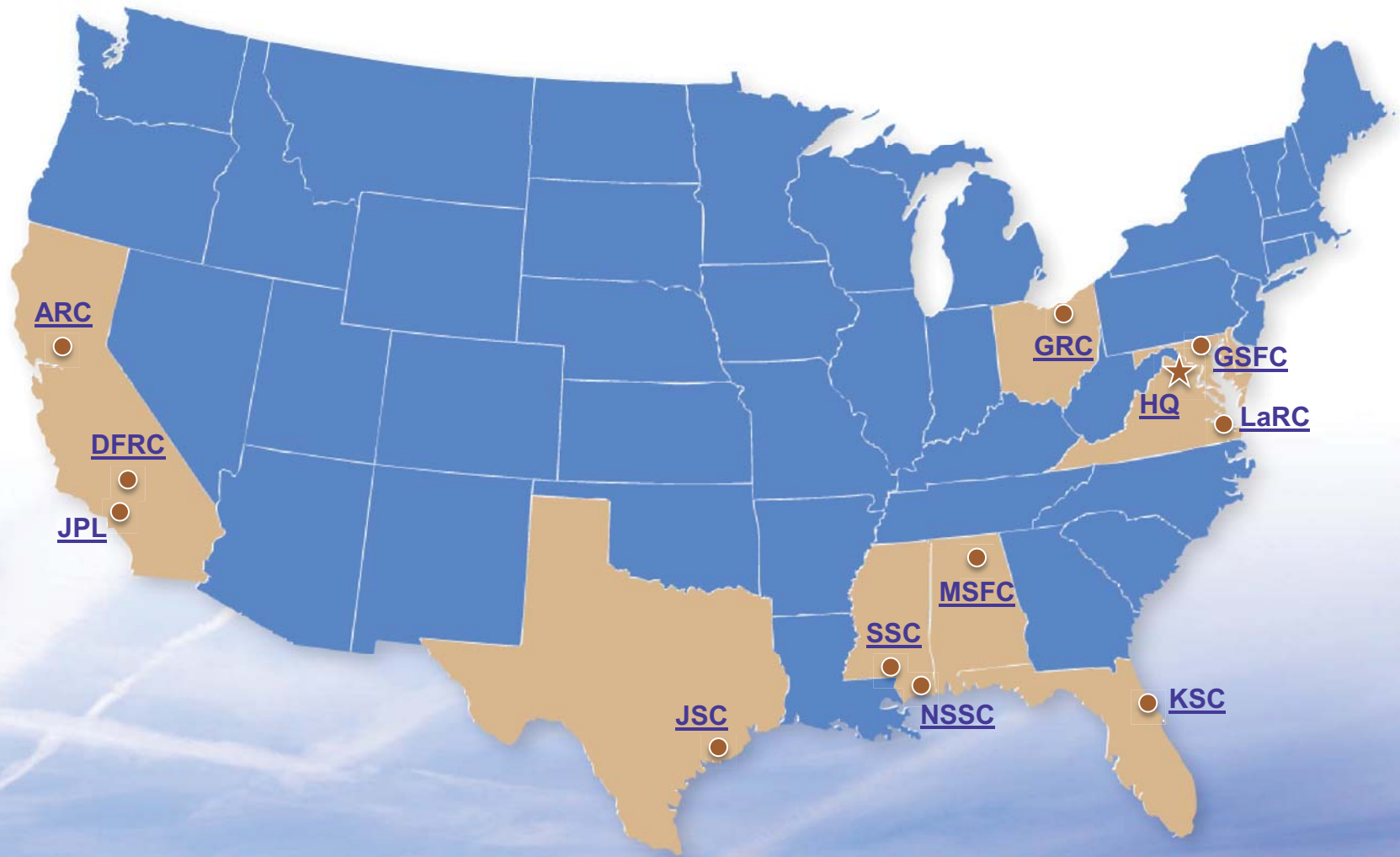


Orion PA-1 Launch Abort System



DC-8

# NASA Centers







# Center Locations

Edwards AFB, California

Palmdale, California



# Dryden Aircraft Operations Facility (DAOF)

Palmdale



- U.S. Air Force Production Flight Test Installation (Plant 42)
- Palmdale Site 9 Complex
  - › Ready access to USAF Plant 42 runway and facilities
  - › 35 miles from NASA Dryden Flight Research Center
  - › 422,000-square-foot floor space, including 210,000 square feet in central hangar area



**Dryden Online**  
Click for more details



## Science Mission Directorate

### NASA observes the Earth from Space

- Satellite calibration and validation
- New sensor and algorithm development
- Process studies
- Next generation NASA scientist and engineer development

## Suborbital Research Platforms

- NASA Armstrong operates 6 “Core” science research platforms and 2 “As Required” platforms
  - Core: DC-8, ER-2 (2), C-20, Global Hawk (2)
  - As Required: B-200, Predator-B (Ikhana)
- We conduct deployed operations around the globe
- High demand for summer and fall deployments requires innovative solutions to meet requirements



# DC-8

## Long-range airborne science laboratory



- Ceiling: 42,000 feet
- Duration: 12 hours
- Range: > 5,400 nautical miles
- Payload: 30,000 pounds
- More than 100 instruments integrated into the DC-8

## DC-8 Highlights

- Operation IceBridge, NASA's airborne mission to study the Earth's polar ice, is in its fourth year
- DC-8 supports atmospheric "greenhouse" gas studies around the globe and satellite instruments development and calibrations



# Airborne Science Program

## Operation IceBridge Antarctic

### *Filling the Ice Cap Knowledge Gap*

#### **DC-8 Science Platform**

Collect data during IceBridge operation to bridge data gap in polar observations between NASA's Ice-, Cloud-, and Land-Elevation Satellite (ICESat), inactivated in 2009, and ICESat-2's planned launch in 2016

#### What's Happening:

- Since 2009, the NASA DC-8 operating out of Punta Arenas, Chile, has supported Antarctic ice studies annually except for 2013 when the NASA P3 made an exploratory trip to McMurdo Station
- NASA's DC-8 is scheduled to return to Punta Arenas, Chile, in October 2014 to continue overflights of the Antarctic Continent's ice sheets and offshore sea ice areas



DC-8 overflies sea ice as part of annual Antarctic ice studies.

#### Partners:

- NASA Glenn Flight Research Center
- NASA Ames Research Center

# Airborne Science Program

## Active Sensing of CO<sub>2</sub> Emissions Over Nights, Days, and Seasons (ASCENDS)

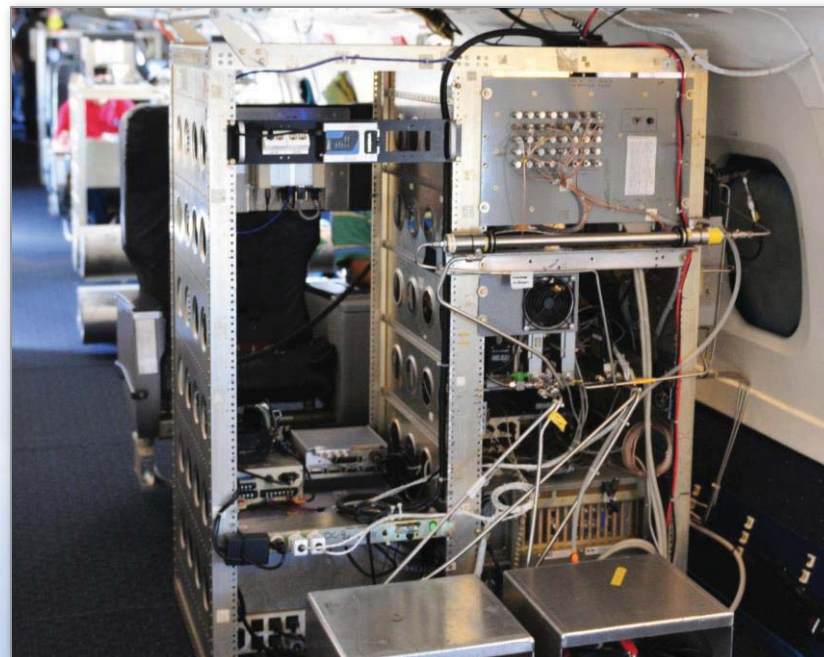
### *Using Aircraft to Develop Satellite Instruments*

#### DC-8 Science Platform

Support NASA's development of future space-based instruments measuring atmospheric CO<sub>2</sub> and O<sub>2</sub>

#### What's Happening:

- During the three previous years the DC-8 has supported the ASCENDS in the development of what are planned to be future Earth orbiting satellite based instruments
- DC-8 again supporting ASCENDS in August-September 2014



CO<sub>2</sub> and O<sub>2</sub> atmospheric remote measuring LIDARs collecting data during flights over varying backgrounds (deserts, forests, oceans, snow).

#### Partners:

- NASA Headquarters, Goddard Space Flight Center, Jet Propulsion Laboratory, and Langley Research Center
- NASA Earth Science Technology Office



# Gulfstream C-20A

## UAV synthetic aperture radar (UAVSAR)

- Ceiling:  
45,000 feet
- Duration:  
6+ hours
- Range:  
> 3,400  
nautical miles
- Payload:  
2,610 pounds



### C-20A (G-III) Highlight

Equipped with Jet Propulsion Laboratory's UAV synthetic aperture radar, platform is used to gather scientific data on earthquake fault zones, volcano glaciers, wetlands, and surface deformation regions for geological studies.

# Airborne Science Program

## Subsidence and Oil Spills – New Orleans

### *Imaging Louisiana's Gulf Coast*

#### **Gulfstream C-20A Science Platform**

Study causes of subsidence of Gulf Coast and predict future subsidence rates to determine how to manage protection of infrastructure

#### What's Happening:

Imaged the Gulf Coast in late March 2014;  
expect to return to the Gulf Coast in late  
August 2014



NASA tail number 502 on the ramp in New Orleans.

#### Partners:

- Jet Propulsion Laboratory
- U.S. Department of Homeland Security



# Airborne Science Program

Fault Lines, Delta Levees, and Landslides – California, Colorado, and Mexico

## *Imaging Sacramento Delta Levees, San Andreas Faults, and Slumgullion Landslides*

### **Gulfstream C-20A Science Platform**

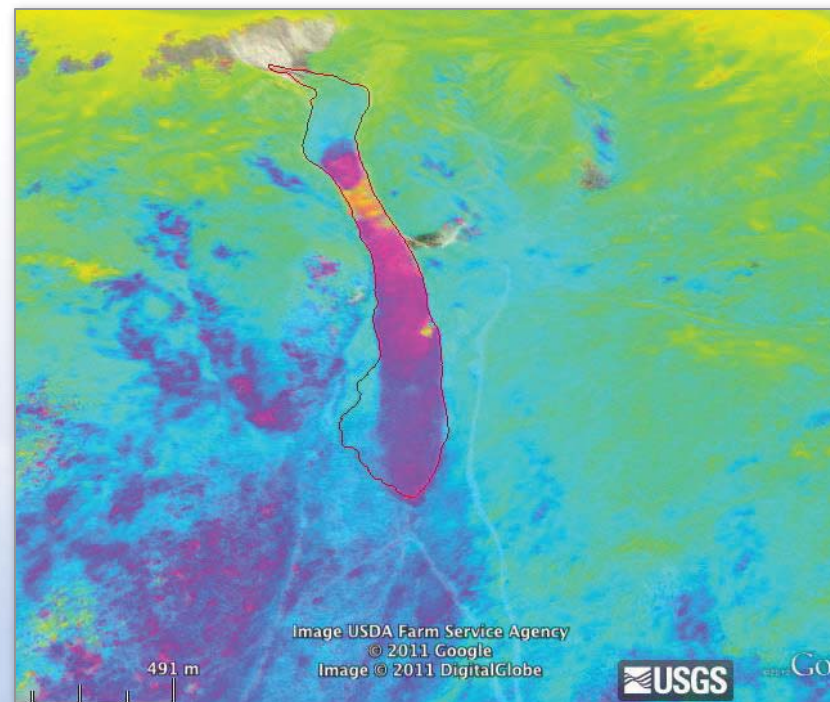
Monitor Sacramento Delta (under continuous threat of levee failure)

Study surface deformation of San Andreas Faults to understand fault slip variations

Understand mechanisms controlling landslide motion

### What's Happening:

- Imaged northern and southern California, plus the Colorado Slumgullion region in March 2014
- Acquired more data during Summer 2014



UAVSAR image Colorado Slumgullion Landslide

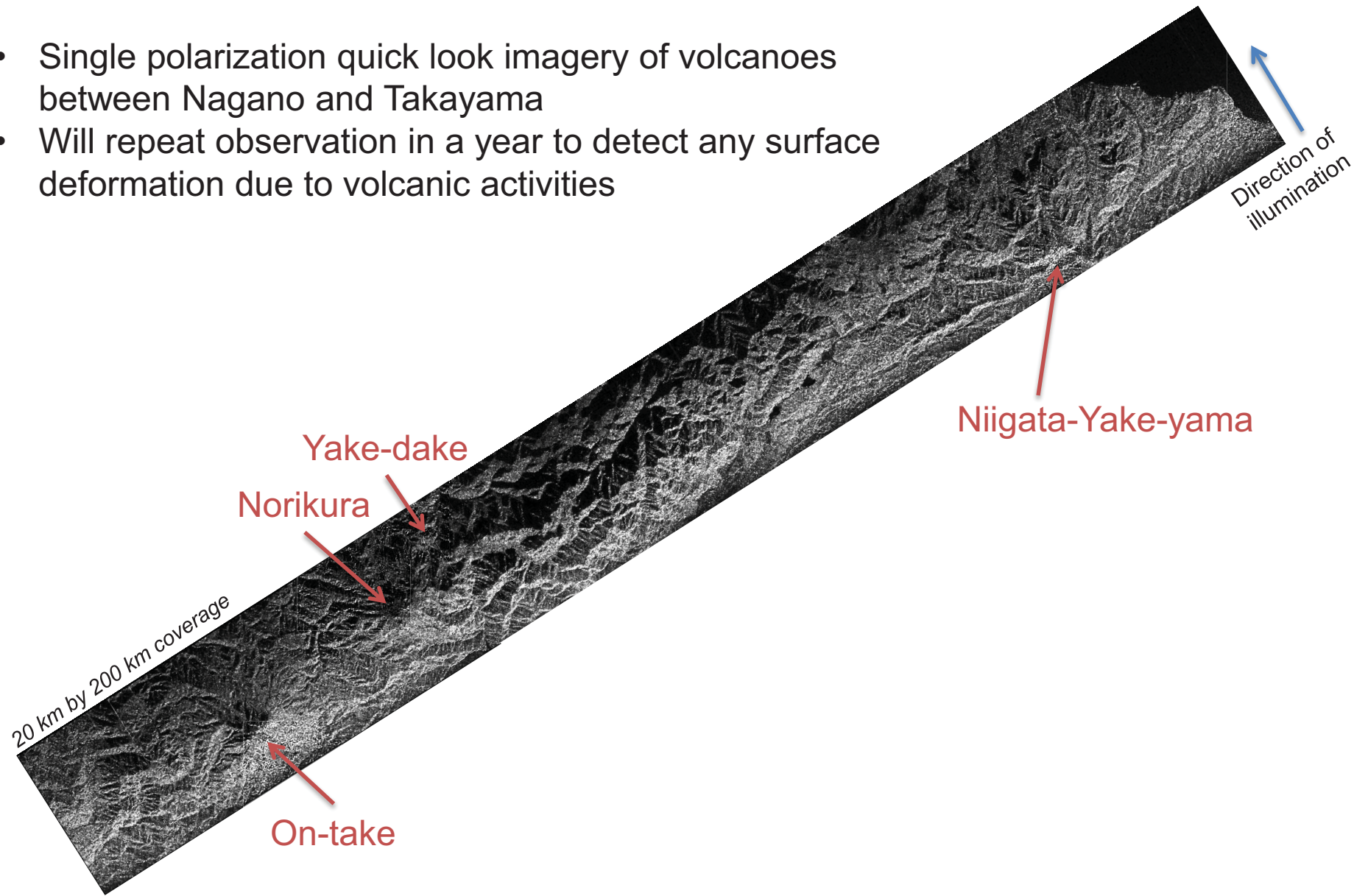
### Partner:

- Jet Propulsion Laboratory

**+ Link: NASA Model Provides a 3-D Look at L.A.-Area Quake**

## First Look Japan Image

- Single polarization quick look imagery of volcanoes between Nagano and Takayama
- Will repeat observation in a year to detect any surface deformation due to volcanic activities





# ER-2

## High-altitude science platform



- Ceiling:  
> 70,000 feet
- Duration:  
> 10 hours
- Range:  
> 6,000  
nautical miles
- Payload: 2,600  
pounds

### ER-2 Highlights

- Hyper- and multi-spectral imaging aided in assessing the environmental impact of the 2010 Gulf Oil Spill
- In 2012, deployed to Iceland and NASA's Wallops Flight Facility for research using a new laser altimeter, the Multiple Altimeter Beam Experiment LIDAR (MABEL), which was developed at NASA's Goddard Space Flight Center

# Airborne Science Program

## Satellite Simulators

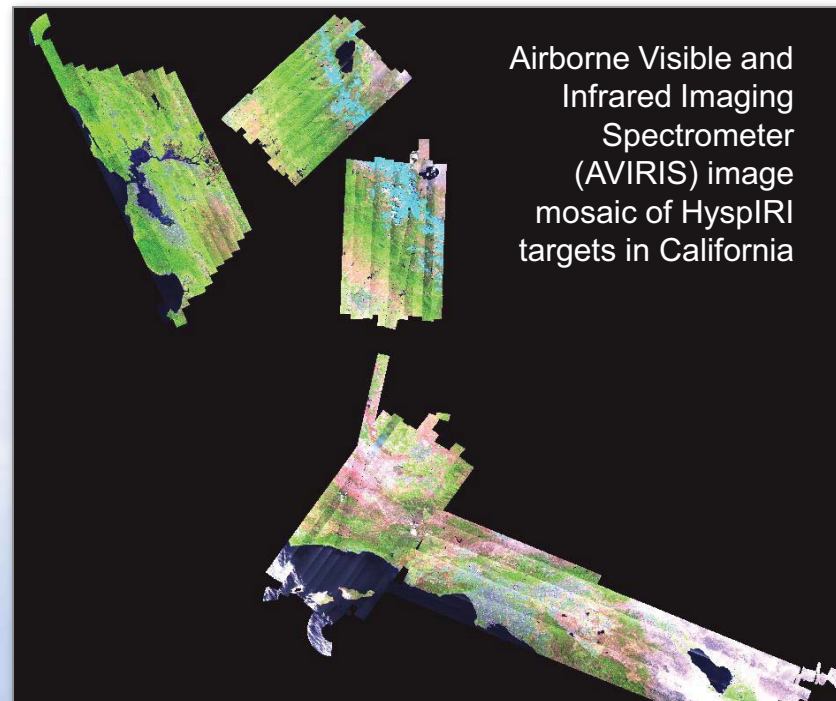
### *Developing NASA's Next Generation Earth-Observing Satellites*

#### ER-2 Science Platform

High-altitude flights conducted to calibrate, validate, and develop algorithms for Earth science satellites

#### What's Happening:

- Completed 21-flight, 113-hour Integrated Precipitation and Hydrology Experiment (IPHEX) campaign May-June 2014 in Warner-Robins, Georgia
- Completed 12-flight, 76-hour Multiple Altimeter Beam Experimental LIDAR (MABEL) campaign July-August 2014 in Fairbanks, Alaska
- Supporting Hyperspectral Infrared Imaging (HyspIRI) flights August-October 2014



Airborne Visible and Infrared Imaging Spectrometer (AVIRIS) image mosaic of HyspIRI targets in California

#### Partners:

- Jet Propulsion Laboratory
- NASA Goddard Space Flight Center and other NASA Centers
- Multiple universities

**+ Link: Collecting Data on Earth's Ecosystems**

SMD

# Global Hawk

Long range, high altitude, high endurance UAV

- Endurance:  
> 30 hours
- Range:  
> 10,000 miles
- Service ceiling:  
65,000 feet
- Payload:  
1,000-1,500 pounds



## Global Hawk Highlight

Global Hawk flew five science missions over Tropical Storm/Hurricane Nadine, plus the transit flight circling around the east side of Hurricane Leslie, in September 2012.



# Airborne Science Program

## Airborne Tropical Tropopause Research Experiment (ATTREX) Climate Study

### *Predicting Changes in Stratospheric Humidity*

#### Global Hawk Science Platform

Study physical processes in Tropical Tropopause layer of atmosphere to better understand Stratosphere

Platform equipped with science instruments that collect air samples scientists use to study chemical composition of Tropical Tropopause

#### What's Happening:

- ATTREX missions were conducted at Guam from January to March 2014
  - › 12 science instruments were integrated on tail number (TN) 872, including the wing-mounted Hawkeye
  - › Seven ATTREX science data gathering flights were completed for a total of 121 hours
  - › Flights in Japanese and Australian airspace



ATTREX 2014 Missions

#### Partners:

- Northrop Grumman Aerospace Systems
- National Oceanic and Atmospheric Administration (NOAA)

**+ Link: NASA Brings Science to Life in Guam**

# Airborne Science Program

## Hurricane and Severe Storm Sentinel (HS3)

### *Predicting How Tropical Storms and Hurricanes Are Formed*

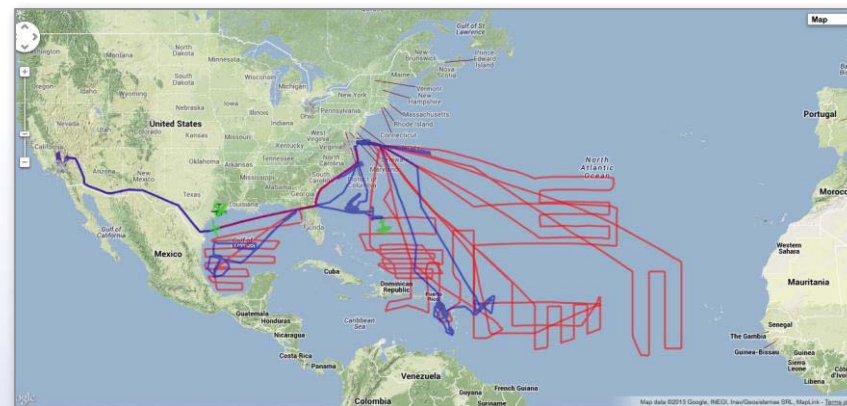
#### Global Hawk Science Platform

Equipped with science instruments, unmanned Global Hawk monitors environment around storms, looking for conditions favorable for storm formation and intensification

Second Global Hawk flies directly over storms to collect data on inner-core structures that lead to storm intensity change

#### What's Happening:

Two Global Hawks deployed August-September 2014 to Wallops Flight Facility for missions during the Atlantic Basin hurricane season



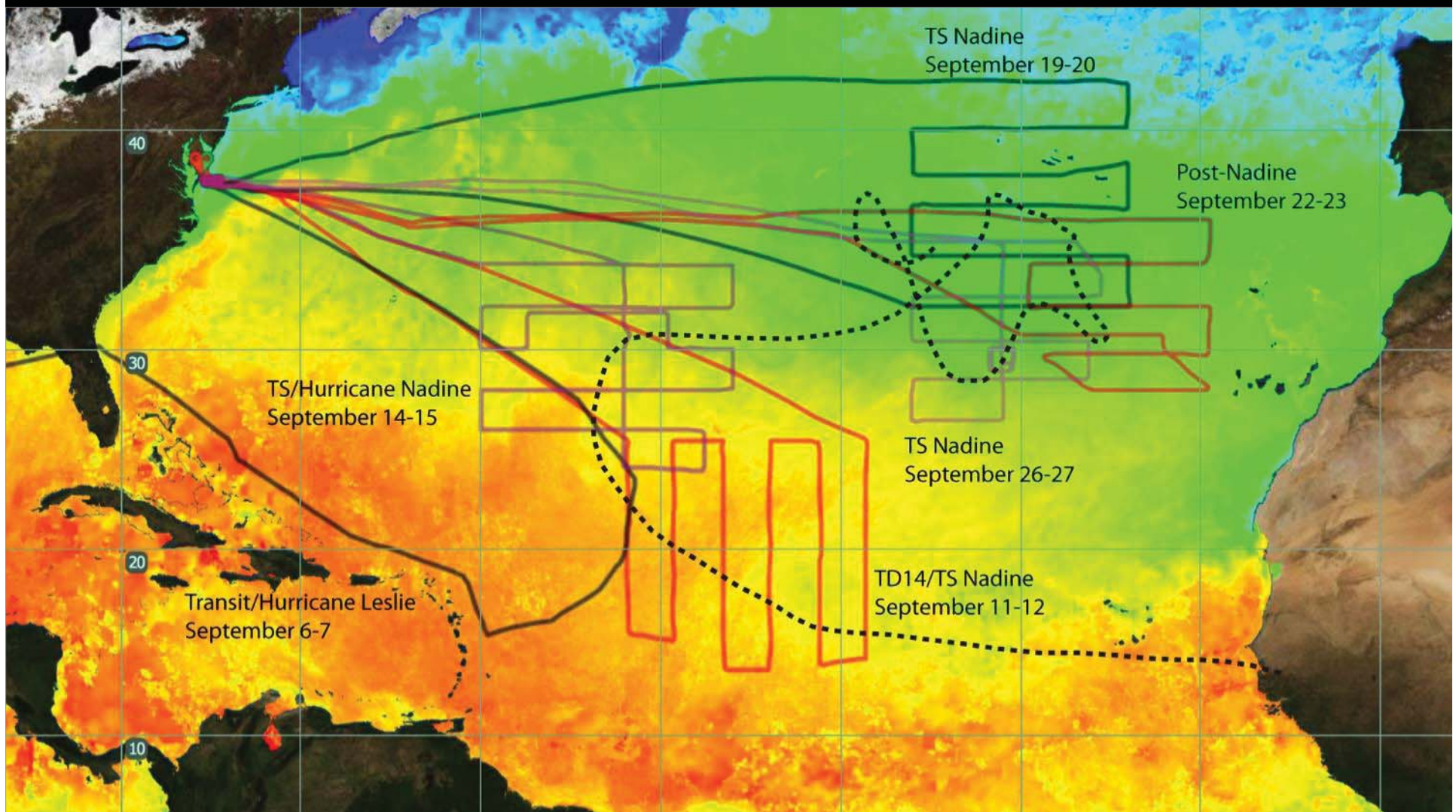
HS3 2013 Missions

#### Partners:

- Northrop Grumman Aerospace Systems
- NOAA



# Global Hawk flies over and around hurricanes Nadine and Leslie. September 2012





# Airborne Science Program

## Laser Vegetation Imaging Sensor (LVIS) Arctic Flight

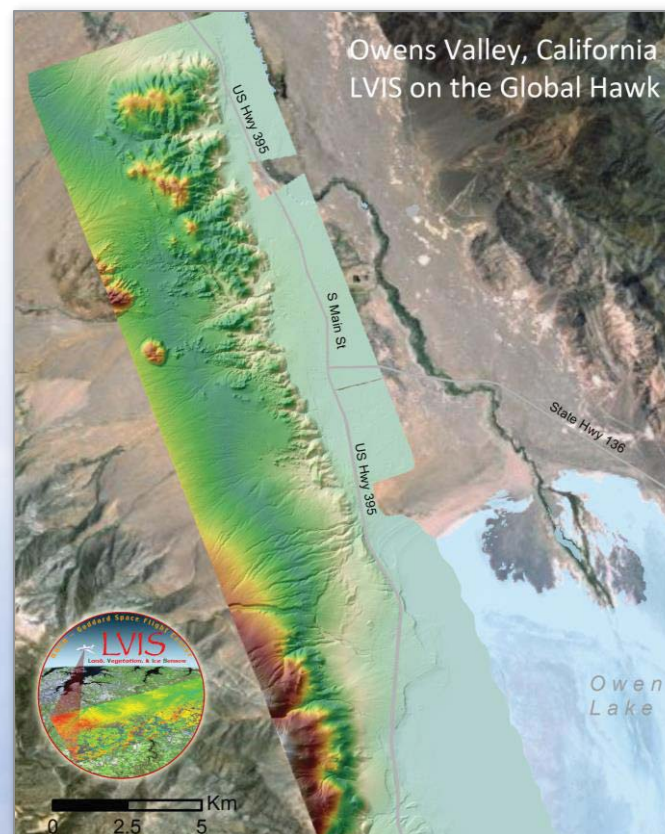
### *Studying Earth's Topography, Hydrology, and Vegetation*

#### Global Hawk Science Platform

Combined with aircraft position and attitude information, the LVIS collects data to produce topographic maps of vertical height and structural measurements of various vegetation

#### What's Happening:

- LVIS was integrated on TN 871 and flown for the first time in June 2013
  - › A 7-hour mission was flown within the Edwards AFB range to check out operation of the instrument
  - › Instrument operated nominally and data was collected during the mission



LVIS data from the range flight

#### Partner:

- Northrop Grumman Aerospace System

## King Air (B-200)



### Research, mission support aircraft

- Service ceiling:  
32,800 feet
- Payload:  
Up to 11 passengers;  
400 pounds baggage



### King Air (B-200) Highlights

- Hi-rate Wireless Airborne Networking  
Demonstration tested wireless modem and data transmission capability over the Internet from the aircraft
- The X-38 Space-integrated GPS inertial navigation system experiment led to the guidance, navigation, and control system used on the International Space Station

# Airborne Science Program

## Airborne Surface Water and Ocean Topography (AirSWOT)

### *Measuring Earth's Water Resources and Ocean's Affect on the Atmosphere*

#### **King Air (B200) Mission Support Aircraft and Science Platform**

Gathering data off California coast, Ka-band radar interferometer helps science team determine kinetic energy of ocean circulation and how ocean uptake of heat and carbon is being transferred into the atmosphere

#### What's Happening:

- Full AirSWOT payload of Ka-band SWOT Phenomenology Airborne Radar (KaSPAR) and Digital Camera System (DCS) is integrated and system performance is being evaluated with ground and airborne activities
- Ocean topography and hydrology missions planned September 2014 to January 2015



King Air (B200)

#### Partner:

- Jet Propulsion Laboratory



# Ikhana

## Predator B UAS adapted for science missions

- Ceiling: > 40,000 feet (high 30,000s for sustained operations with payloads)
- Duration: > 24 hours
- Payload: Potential for 2,000+ pounds)
- Deployable worldwide



Ikhana is NASA's primary UAS in the medium-altitude and long-endurance class.



**Dryden Online**  
Click for more details

# Ikhana

## MQ-9 Predator B UAS Adapted for Science and Research Missions

### *World-Class UAS Capability*

NASA's primary UAS in the medium-altitude, long-endurance class; deployable world-wide

USAF Block 1 configuration: sustainable and compatible with majority of fleet and associated ground support systems

Aircraft reconfigurable to U.S. Air Force or Customs and Border Protection (CBP) configurations

Reconfigurable science pod available (> 500 pounds of payload)

#### What's Happening:

Project team is preparing Ikhana to conduct Airborne Collision Avoidance System (ACAS)-Xu flights in support of the NASA UAS Integration in the NAS project

Ikhana in maritime configuration



**Ceiling:** > 40,000 feet (high 30,000s for sustained operations with payloads)

**Duration:** > 24 hours

**Payload:** Potential for 2,000+ pounds

**Range:** > 3,000 miles

#### Partners:

- General Atomics-Aeronautical Systems, Inc.
- Raytheon
- U.S. Air Force

# Ikhana

NOAA Science and U.S. Navy Rim of the Pacific Exercise (RIMPAC) 14

## *Demonstrating UAS and Sensor Technology for Science, Navy Ops*

### NOAA/RIMPAC Missions:

Conduct disaster relief exercise

Support fisheries protection against affects of illegal foreign fishing activities

Track marine mammals;  
What's Happening:  
enable future science

First Ikhana deployment late June to mid August 2014 to Hawaiian Islands

Provide intelligence,



Ikhana in maritime configuration

### Partners:

- General Atomics-Aeronautical Systems, Inc.
- Raytheon



## Operational Challenges

- Conducting simultaneous deployments presents scheduling challenges
  - Define missions up to 2 years in advance
  - Lock in dates at the beginning of the Fiscal Year
- Simultaneous missions strains the resources
  - Try to limit the length of time people are on deployment
  - Require a break in between deployments
  - For long deployments we plan on swapping crews
- Good logistical planning is essential for success
  - › Taking care of people
  - › Taking care of assets
- Detailed planning and coordination among deployed crew is essential to insure success

## Summary

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- NASA Armstrong operates a number of suborbital platforms to support NASA's science mission
- Each platform fills a unique niche to gather critical science data
- There are a number of operational challenges in deploying aircraft around the world
- NASA Armstrong has a dedicated group of people who enable the success of the NASA science mission

